

arrival along the Ewa coastline near the entrance to Pearl Harbor on Oahu's southern shore. The Argos system relayed 28 positions of relatively high quality during the migration. After reaching the Ewa coastline, transmissions continued on nearly a daily basis for over six months, thereby clearly demonstrating the turtle's extended residency to this area.

The migratory pathway of female 22132 was substantially farther to the south than the routes followed by the two male turtles. However, the route of female 22132 was very similar to three of the four post-nesting females satellite-tracked in past years migrating from French Frigate Shoals to Oahu (Balazs, 1994; Balazs *et al.*, 1994).

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GROWTH RATES AND RESIDENCY OF IMMATURE GREEN TURTLES AT KIHOLO BAY, HAWAII

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Long-term studies of green turtles, *Chelonia mydas* (honu), in nearshore waters of the Hawaiian Islands have been underway to obtain comprehensive information on growth rates, food sources, habitat use, developmental and reproductive migrations, underwater behaviors, health status, and population trends (Balazs, 1980, 1982, 1991, in press; Balazs *et al.*, 1987, 1993, 1994a, 1994b; Russell and Balazs, 1994). The Hawaiian Archipelago includes 132 islands and reefs extending for 2400 km across the North Pacific. However, the eight main islands at the southeastern end of the chain account for nearly all coastal benthic habitats suitable for foraging and resting by post-pelagic green turtles. Adult

males and females residing throughout the chain migrate to breed at isolated French Frigate Shoals (23° 47'N, 166° 12'W) situated at the mid-point of the archipelago (Balazs, 1976, 1980, 1983). Systematic monitoring at this site for 23 consecutive seasons (1973-95) has documented an approximate threefold increase in the number of nesting females (Fig. 1). This encouraging sign of population recovery is attributed to protection extended in 1978 under the U.S. Endangered Species Act. Similar increases have been seen for immature turtles inhabiting nearshore waters of the main islands, such as reported here for Kiholo Bay.

METHODS

Kiholo Bay and the adjoining 2 hectare mixohaline lagoon known as Wainanali'i Pond are located at 19° 52'N, 155° 55'W on the western coast of the island of Hawaii (Kay *et al.*, 1977). This site constitutes one of 16 resident areas for green turtles under investigation throughout the Hawaiian Islands. Kiholo Bay has been periodically visited for tagging since 1980 involving 27 expeditions lasting from 1 to 4 days. Since 1987, students and science instructors from the Hawaii Preparatory Academy have served as essential field assistants in the accomplishment of this work. Turtles have been harmlessly hand-captured while snorkeling at night or by using large-mesh tangle nets carefully tended to prevent injury from forced submergence. Turtles have also been intensively monitored by sonic telemetry at selected intervals to determine daily foraging and resting schedules (Laber and Waller, 1994).

RESULTS

As of December 1995, 313 green turtles of immature sizes ranging from 33.2 to 71.5 cm in straightline carapace length have been captured and tagged at Kiholo Bay. Nearly all of the turtles were caught by hand while they were resting on the bottom within Wainanali'i Pond or by net while they were passing through the pond's narrow entrance channel. The number of turtles captured on each trip during recent years has increased considerably. For example, during the late 1980s 11 to 37 turtles were captured on each visit. During the 1990s, from 40 to 85 turtles have been captured each time with equal or reduced capture-effort. On recent trips, it has sometimes even been necessary to terminate netting because too many turtles were being caught, thereby exceeding the capacity to expeditiously handle them. Besides green turtles, three juvenile hawksbills have been captured, tagged, and resighted within Wainanali'i Pond.

Of the 313 turtles, 210 or 67.1% have been recaptured one or more times, and 202 (64.5%) provided growth increments ranging from 3 months to 14.4 years. Multiple recaptures of the same turtles yielded 528 growth increments. Re-

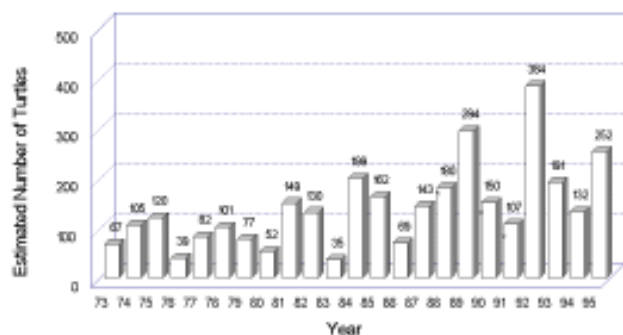


Figure 1. Historical trend for 23 nesting seasons, 1973-95. East Island accounts for 50% or more of all green turtle nesting at French Frigate Shoals. *1988-92 counts based on saturation tagging throughout the nesting season.

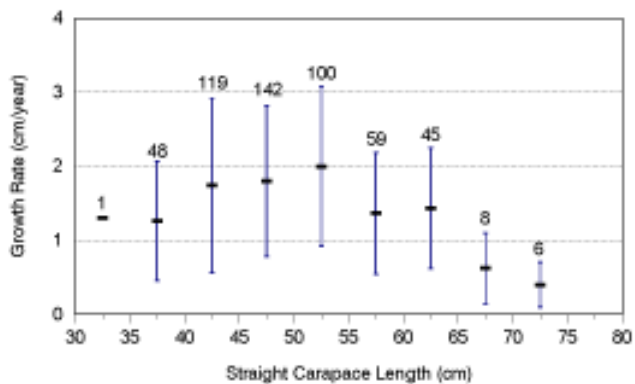


Figure 2. Mean growth rates, standard deviations, and number of growth increments for nine size classes of green turtles at Kiholo Bay, Hawaii. The mean rate of growth for 528 increments (202 turtles) was 1.7 ± 1.0 cm/year.

captures consisted of 32% being recaptured once, 27% twice, 35% 3-5 times, 6% 6-8 times, and one turtle recaptured 13 times (over 7.3 years). The 528 increments, shown in Figure 2 by 5-cm size classes, resulted in an overall mean growth rate of 1.7 ± 1.0 cm/yr. The 50-55 cm size class exhibited the highest mean growth rate (2.0 ± 1.1 cm/yr). When only one growth increment was used for each of the 202 recaptured turtles (i.e., growth between initial and most recent capture) the overall mean growth rate was 1.5 ± 0.8 cm/yr.

Only four turtles (1.3%) tagged at Kiholo have been recaptured elsewhere. Two were found at Kahalu'u Bay 35 km to the south, one at Keawa Nui Bay 12 km to the north, and one at Puako 16 km to the north. The turtle resighted at Puako was recaptured later back at Kiholo Bay. None of the turtles captured at Kiholo over the 14.4-year period were found to have been tagged elsewhere. This is in spite of the fact that 236 green turtles have been tagged since 1990 at other study sites within 16 km to the north, and 50 km to the south, of Kiholo Bay. In addition, 217 green turtles have been tagged at Punalu'u Bay since 1976 on the east coast of the island of Hawaii (Balazs *et al.*, 1994b). Considered together, these data provide strong evidence in support of extended residency for turtles inhabiting discrete coastal sites on the island of Hawaii. Similar findings have resulted from work conducted elsewhere in foraging pastures throughout the Hawaiian Islands.

Sonic telemetry of 10 green turtles involving 500 hours of monitoring (270 hours diurnal and 230 hours nocturnal) revealed extremely limited movements in the turtles' daily cycles at Kiholo Bay. Nights were spent inside Wainanali'i Pond where the turtles are known to rest under submerged lava rock ledges or on the silty bottom where the maximum depth is less than four meters. During the early morning, usually just before sunrise, the sonic-tagged turtles would leave the pond to feed on *Gelidium* and other benthic algae in the adjacent nearshore waters of the bay.

None of the turtles captured at Kiholo Bay or anywhere else along the western coast of the island of Hawaii have had tumors indicative of fibropapillomatosis or evidence of any other disease. However, since 1988, nine carcasses have been

recovered suggestive of fatalities from gillnet fishing that commonly occurs at Kiholo Bay.

Terrestrial emergences by green turtles are occurring with increasing frequency on the smooth lava rock bordering Wainanali'i Pond (see Balazs in press). All turtles examined ashore engaged in this behavior have been healthy and vigorous. Terrestrial basking by green turtles has been known for centuries in the remote Northwestern Hawaiian Islands (Whittow and Balazs 1982). However, until recently, emergence of this nature has been exceedingly rare in the main islands, and never before recorded at Kiholo Bay.

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